Low Corrosion Rate Determination in Hydrazine, Monomethylhydrazine, and MON1 Propellants

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Relatively high corrosion rates for 304 stainless steel (SS) are predicted in literature, and references are made to iron leaching into hydrazine and its increase with a rising concentration of carbon dioxide (CO_2) in the solutions. This would be a sign of general corrosion. The potential hazard caused by general corrosion during accidental exposure is of concern to NASA as its fuel systems age.

Although there are many different types of corrosion (localized, galvanic, crevice, etc.), the best known and most studied is uniform or general corrosion, which is the type most often encountered at NASA facilities. Damage caused by uniform corrosion is predictable. The corrosion rate gives information on the depth of surface penetration caused by uniform corrosion in the lifetime of a structure as a result of the material's exposure to the environment. Structures can be made more mechanically robust by taking uniform corrosion into account during construction design. Other types of corrosion are less predictable, and are difficult to measure.

Low corrosivity under normal operating conditions is generally tabulated as < 1 mil per year (mpy) (a mil is one-thousandth of an inch). Most alloys used by NASA have excellent corrosion resistance, and are used with fuels like monopropellant hydrazine (MPH) and monomethylhydrazine (MMH), which are not very corrosive. The Chemistry and Materials Section at NASA Johnson Space Center's White Sands Test Facility developed a technique to measure corrosion rates as low as 10^{-3} mpy. This technique consists of 6 or more days of alloy immersion and detection of the corrosion products by inductively coupled plasma-mass spectrometry. This procedure can be used to determine corrosion rates in any fluid that can be evaporated to nonvolatile residue or used directly in the inductively coupled plasma-mass spectrometry instrument, provided that corrosion products of the tested materials are soluble in the immersion fluid.

For fuel systems such as MPH, high purity hydrazine (HPH), or MMH, normal operating and storage conditions are without air and moisture. When exposed to air, MPH, HPH, and MMH absorb CO_2 and form carbazic and methylcarbazic acids, which are known corrosion agents. Because of the possibility of accidental exposure, a 4-year study measured the influence of CO_2 and water contamination in MMH and MPH and yielded useful information on the corrosion rates of alloys frequently used in fuel systems (304 SS, 316 SS, 17-4 SS, and Ti-6Al-4V). The objective was to study the effect of fuel contamination by CO_2 and water on the corrosion rate of the alloys when immersed in fuel while opened to nitrogen or dry air. It was found that the corrosion rates of all four alloys in MMH and MPH, contaminated to different degrees with water and CO_2, did not reach the order of 10^{-2} mpy.

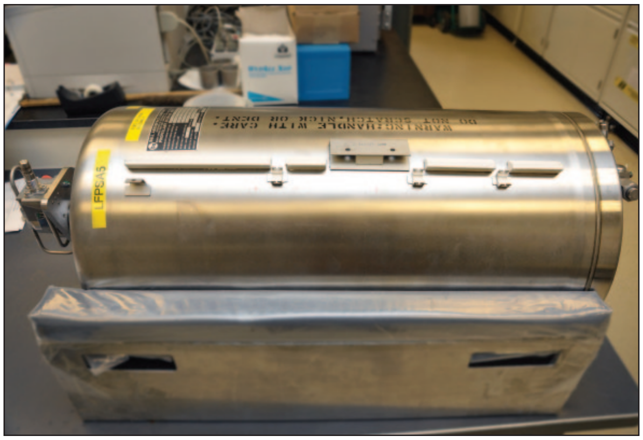

Fig. 1*. Typical fuel propellant storage assembly.*

Also, MMH and MON1 (nitrogen tetroxide with 1% by weight nitric oxide), stored since 1970 in Minuteman propellant storage assemblies made of alloys A 286 and 347 SS (figure 1) were analyzed for the corrosion products of their alloy components. The corrosion rates, conservatively estimated from corrosion products found in the samples, were of the order of 10^{-10} mpy for MMH and 10^{-9} mpy for MON1. These results confirm that propellants can be kept indefinitely when stored properly in containers of compatible materials.